

# AIRS Version-5 Products Verify and Explain Recent Negative Global OLR Trend Observed by CERES

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1. UMBC GEST
2. SAIC



# Background

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- The CERES Science Team OLR products shows a negative global trend on the order of  $-0.1 \text{ W/m}^2/\text{yr}$  from September 2002 through December 2008.
- In a major address at the recent AGU, Kevin Trenberth (NCAR) said CERES must be wrong. He said “this can’t be the case.”
- At a poster at AGU I showed Kevin that AIRS and CERES OLR trends match perfectly. I said “this is the case, but I can’t tell you what is causing it.”
- Our subsequent research explains the meteorological cause of this negative global OLR trend



# Comparison Data Sets

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AIRS Version-5 monthly mean OLR data obtained from Goddard DISC (Level 3)

Presented on a  $1^\circ \times 1^\circ$  latitude-longitude grid

1:30 AM and 1:30 PM monthly mean values extracted separately and averaged together

We use data through December 2009

CERES monthly mean obtained from Langley ASDC

All data presented on a  $2.5^\circ \times 2.5^\circ$  ERBE-like latitude-longitude grid (ES-4)

Edition-1 and Edition-2 CERES CV Terra OLR were both used

Edition-1 extends to December 2009

Edition-2 is more accurate, but extends only to December 2008

CERES Aqua OLR had calibration problems in the early part of the mission and was not used from comparison of anomalies and trends



# Significance of AIRS OLR and Clear Sky OLR

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AIRS OLR is a computed product for each AIRS FOR using an OLR RTA

Input data is AIRS retrieved  $T_{\text{skin}}$ ,  $\epsilon_{\text{w}}$ ,  $T(p)$ ,  $q(p)$ ,  $O_3$ ,  $\alpha\epsilon$ , and  $p_{\text{cloud}}$

AIRS Clear Sky OKR is also computed for each AIRS FOR using same parameters but setting  $\alpha = 0$

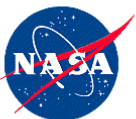
CERES is a measured product

If anomalies and trends of AIRS OLR closely match those of CERES, then:

This validates anomalies and trends of both AIRS OLR and CERES OLR

This indirectly validates anomalies and trends of AIRS retrieved products

In addition, anomalies and trends of OLR can now be attributed to those of its component parts



# Definition of Anomalies and Trends

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For comparison purposes 6-year climatologies were used  
6-year monthly climatologies were generated for each grid box by averaging data for 6 Januaries, 6 Februaries, .....

The monthly average for each grid box is the difference of the value for that month from its climatology

The trend for a grid box is the slope of the straight line passing through the 76 monthly anomalies (September 2002 through December 2008)

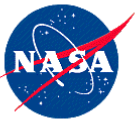
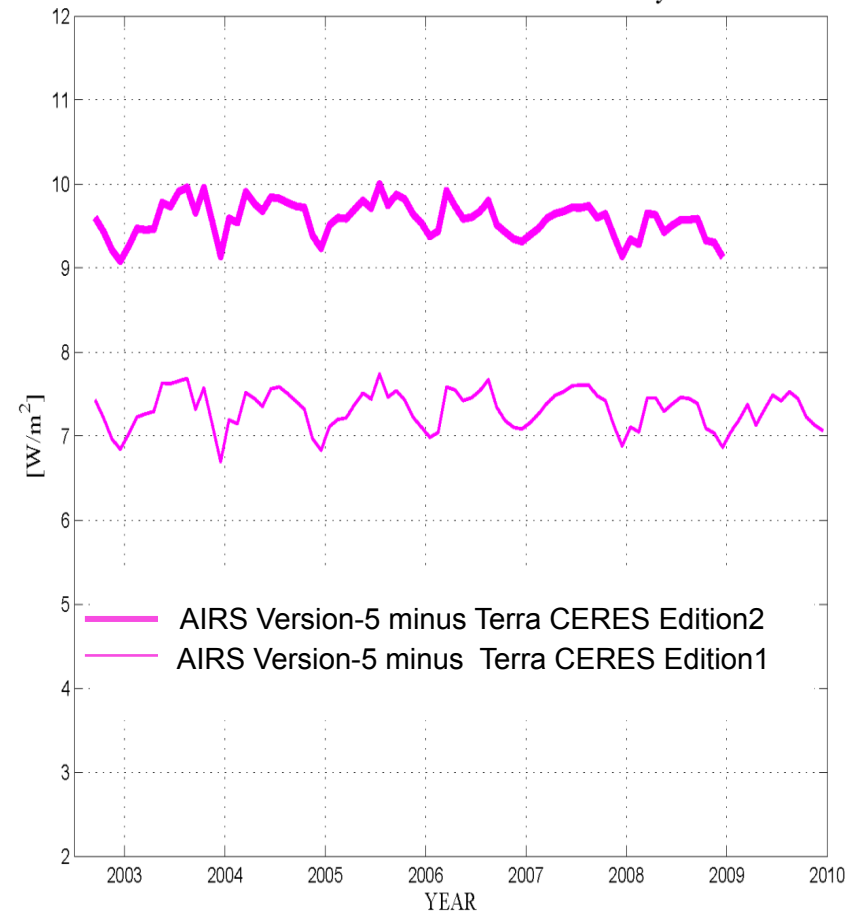
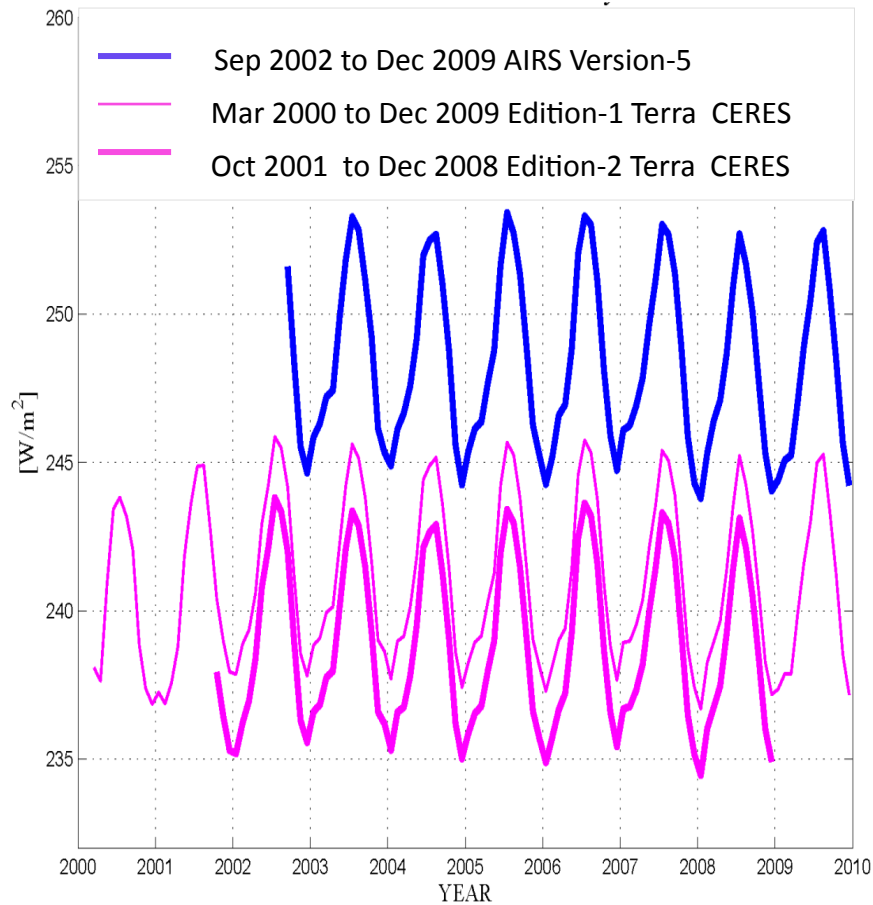
The area mean trend is the cosine latitude weighted average trend over the area

**Monthly anomalies and trends of AIRS and CERES OLR can match well if there is a bias between AIRS and CERES OLR but it is essentially constant in time.**



# Comparison of OLR Observations

September 2002 through December 2009 Time Series of Global All-Sky OLR Differences



# Findings from Time Series of Global OLR

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AIRS OLR and CERES Terra Edition-1 and CERES Terra Edition-2 OLR are all biased with respect to each other with small seasonal cycles

These biases are essentially constant over the 6 to 7-year time period studied

This implies global mean trends of AIRS and CERES Terra OLR might agree well

To first order, the large bias and its small seasonal cycle will be removed in the anomaly time series

AIRS Version 6 OLR uses a new OLR RTA that essentially removes the  $9.6 \text{ W/m}^2$  bias between AIRS and CERES Terra Edition-2 OLR

The new RTA was developed by AER

The improvement is mainly in the characterization of  $\text{H}_2\text{O}$  rotation band near  $300 \text{ cm}^{-1}$

AIRS version 6 OLR is roughly  $9 \text{ W/m}^2$  lower than AIRS version 5 OLR

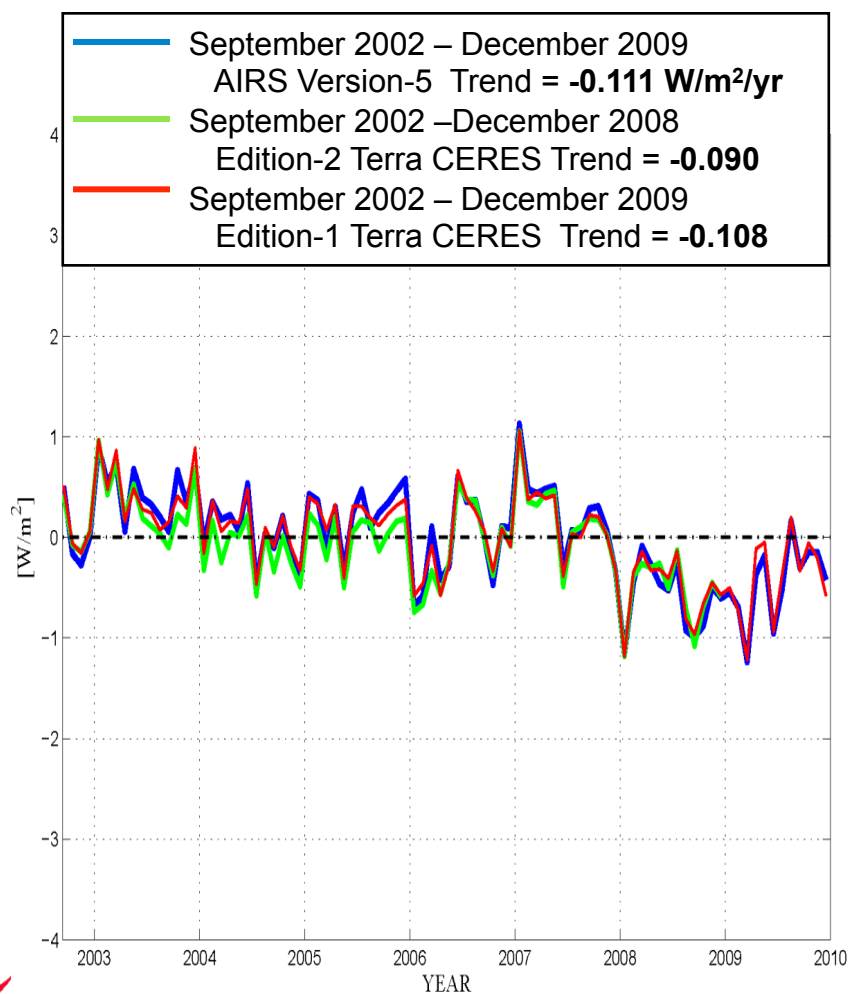


# Comparison of OLR Anomaly Timeseries

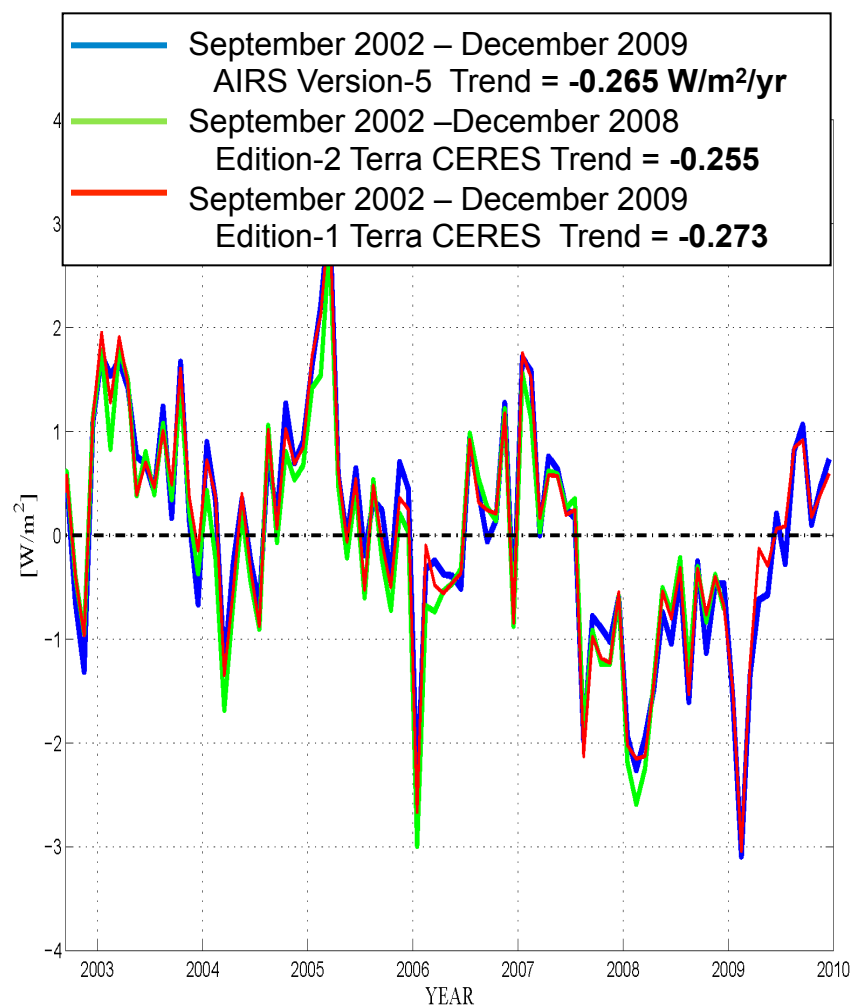
Data for September 2002 through December 2009

Trends cover September 2002 through December 2008

Global



Tropics

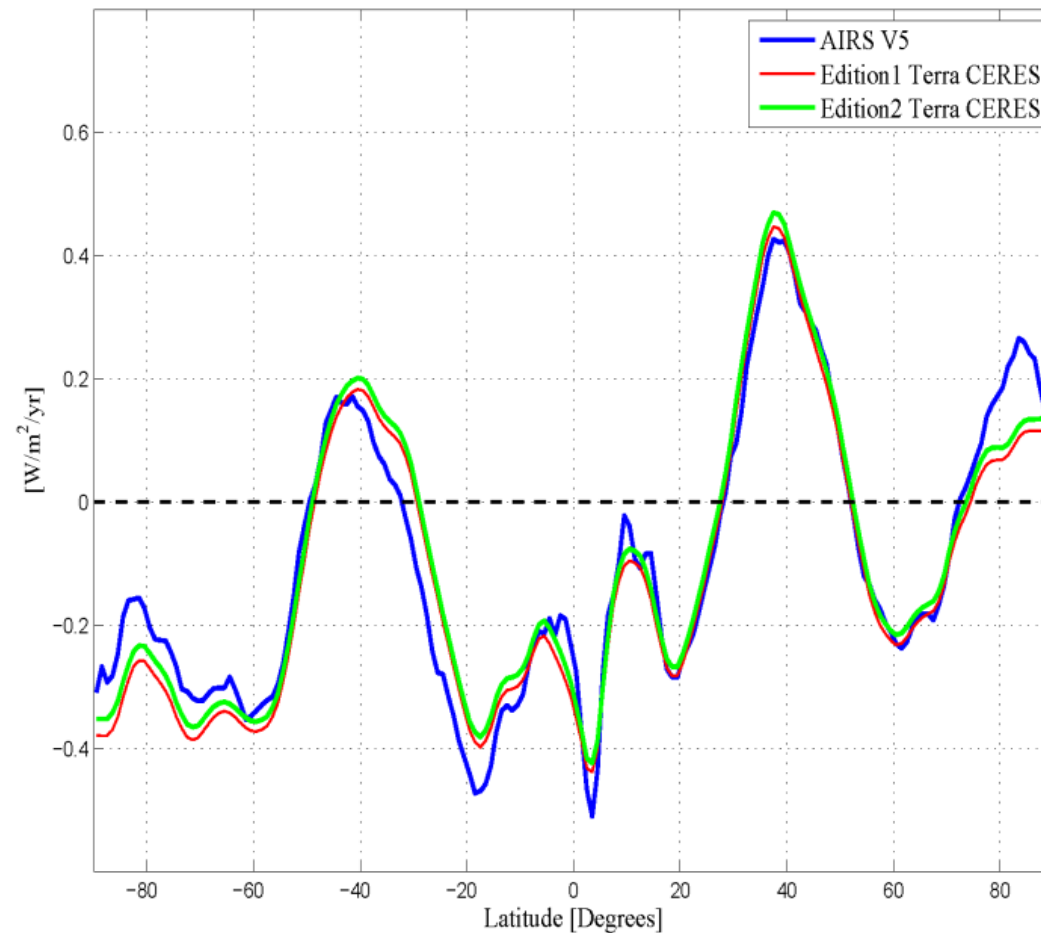




# Comparison of OLR Zonal Mean Trends

September 2002 through December 2008

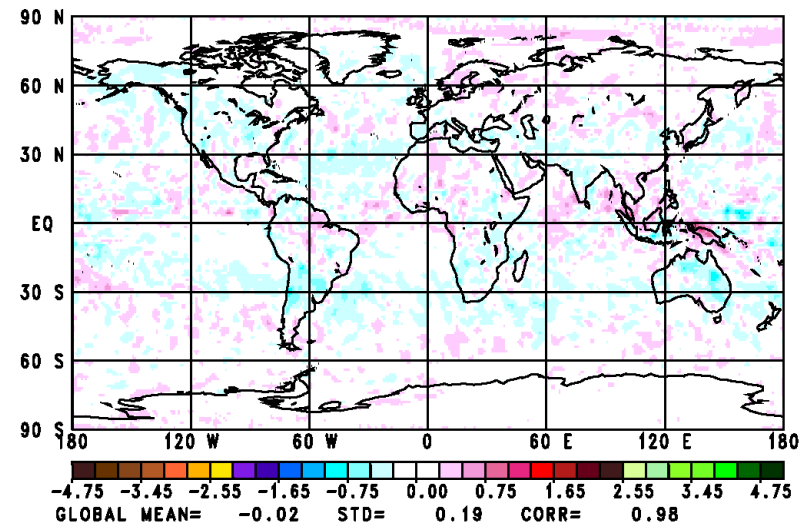
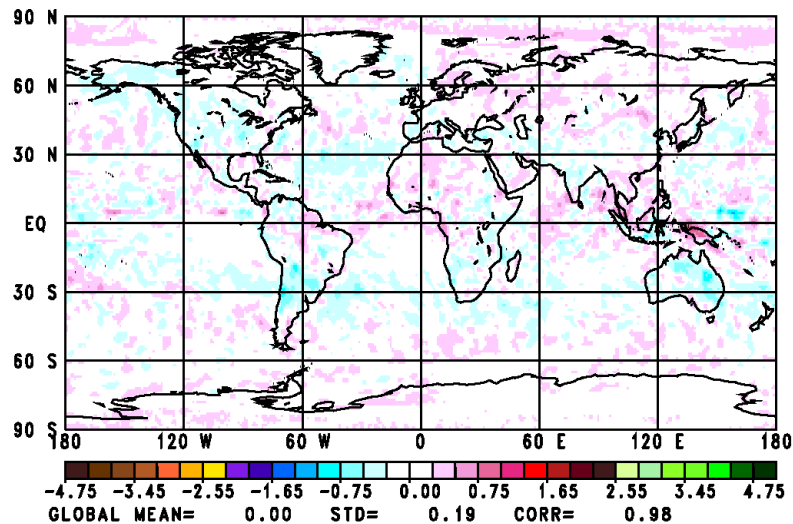
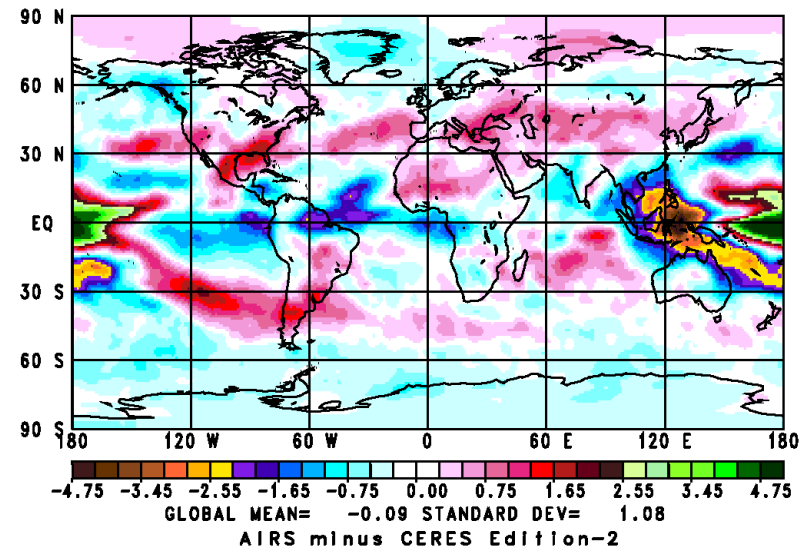
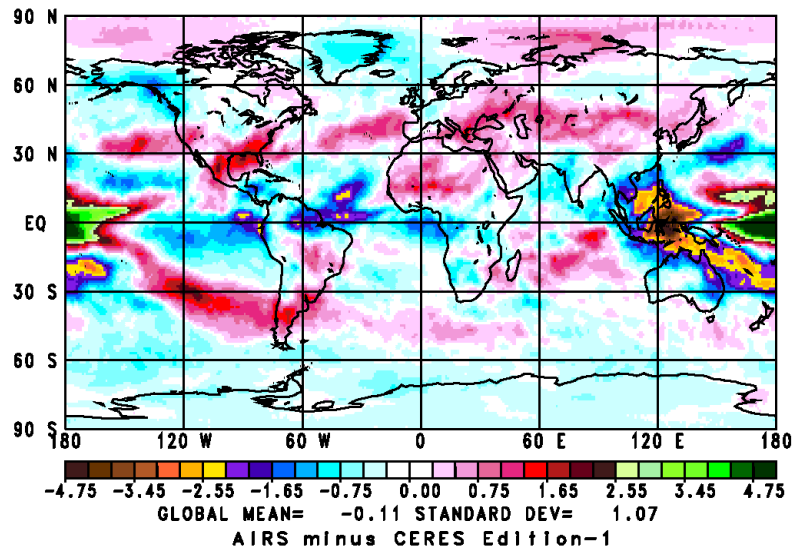
Trend



# Comparison of OLR Spatial Trends

OLR Anomaly Trend  
AIRS

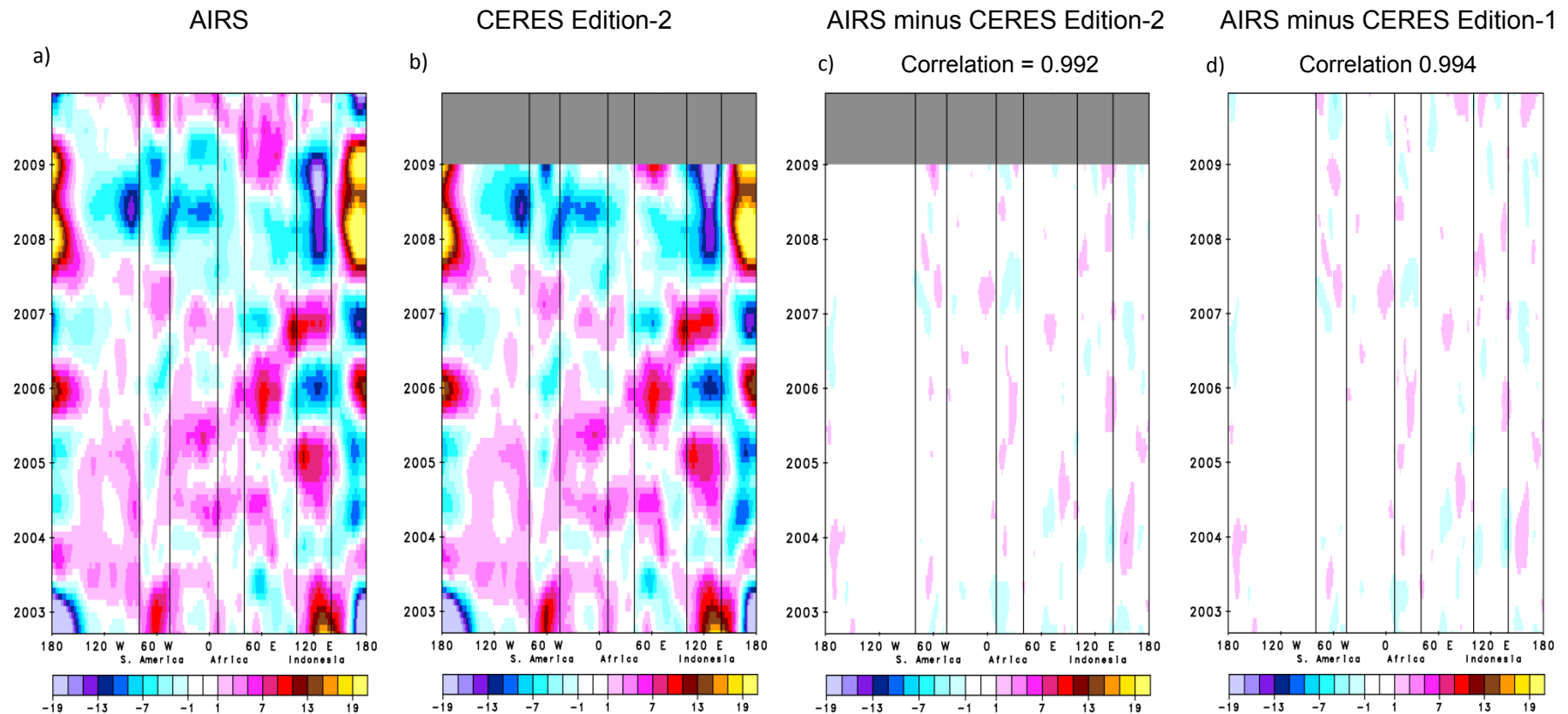
September 2002 through December 2008  
CERES Edition-2



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# Comparison of OLR Anomaly Hovmoller Diagram

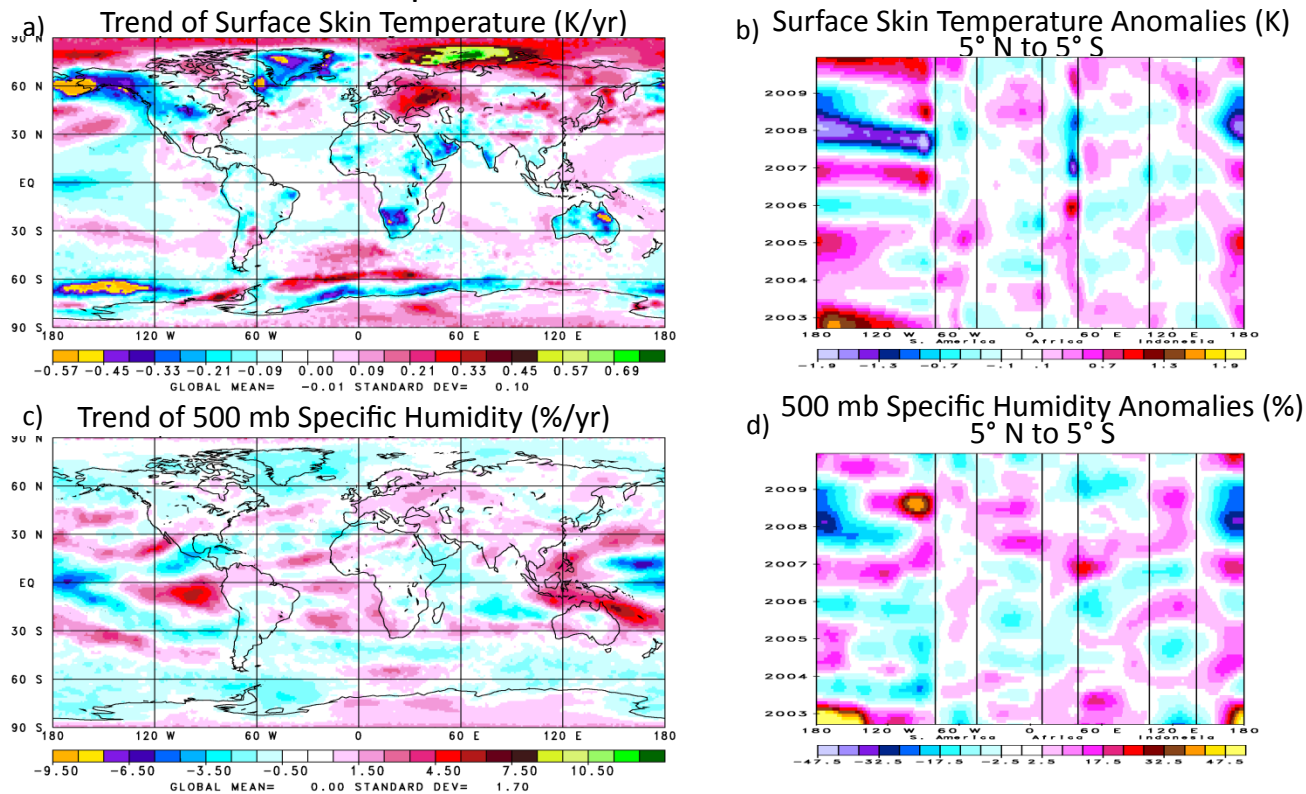
Monthly Mean OLR Anomaly ( $\text{W/m}^2$ ) Tropics  $5^\circ\text{N}$  to  $5^\circ\text{S}$



# Effects of El Niño on Temperature Anomalies and Trends

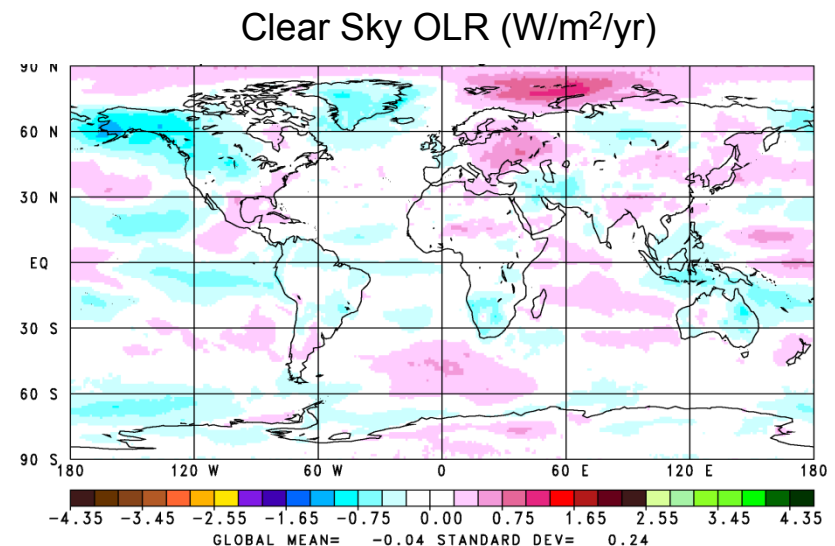
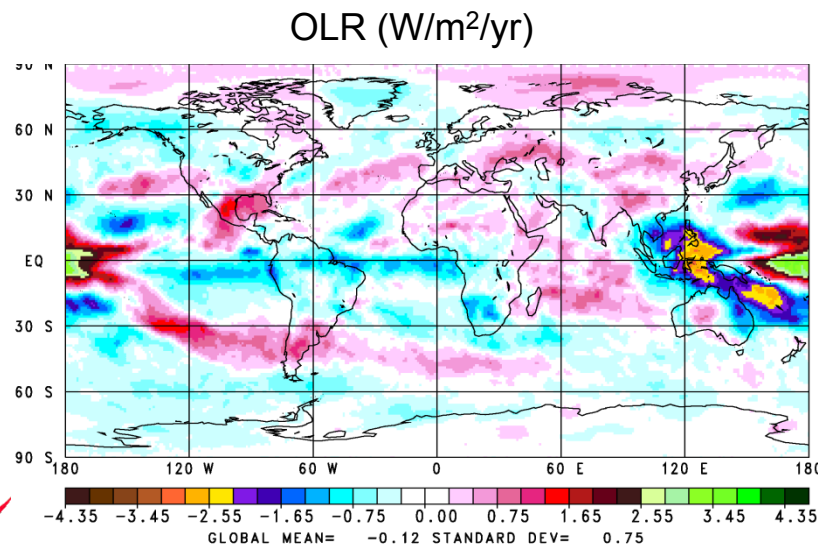
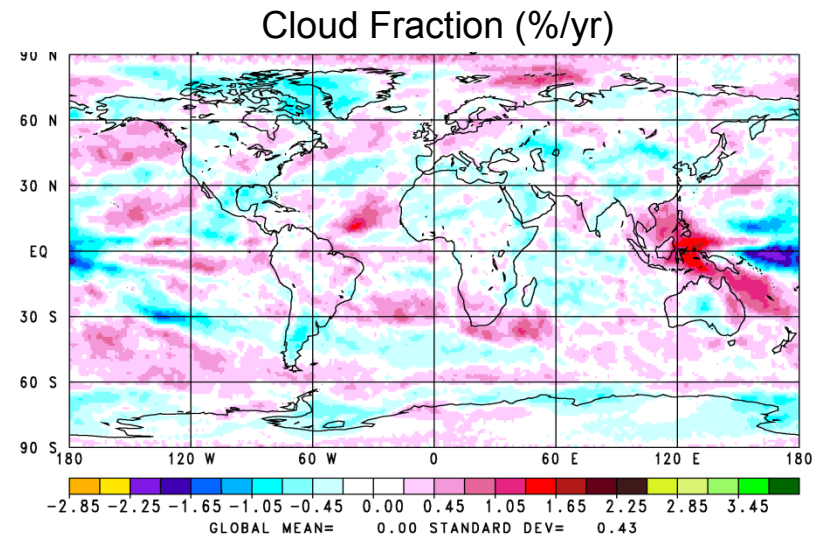
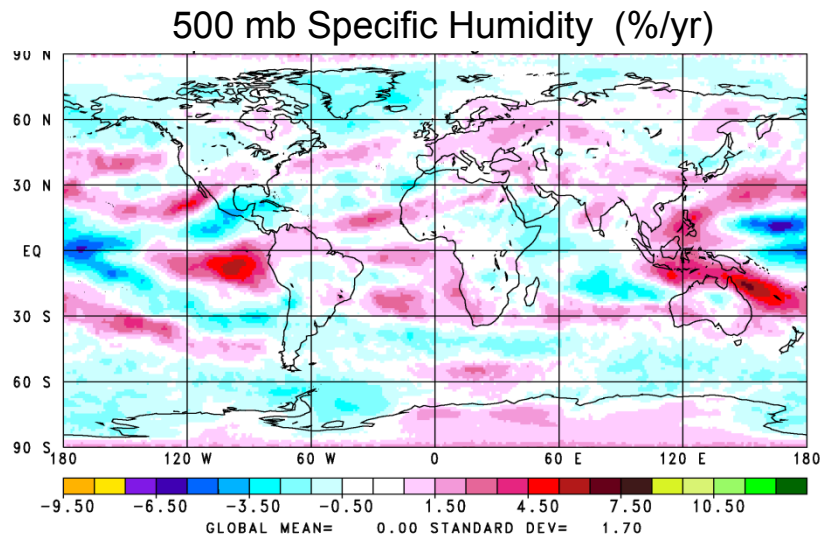
A strong equatorial SST cooling trend exists from 160E to 120W surrounded by a weaker warming ring to the west. A transition occurred from a strong El Niño in late 2002 to a strong La Niña in 2008. Late 2009 is characterized by the beginning of another El Niño.

September 2002 to December 2009



# Effects of El Niño on Water Vapor, Cloud, and OLR Trends

September 2002 through December 2009



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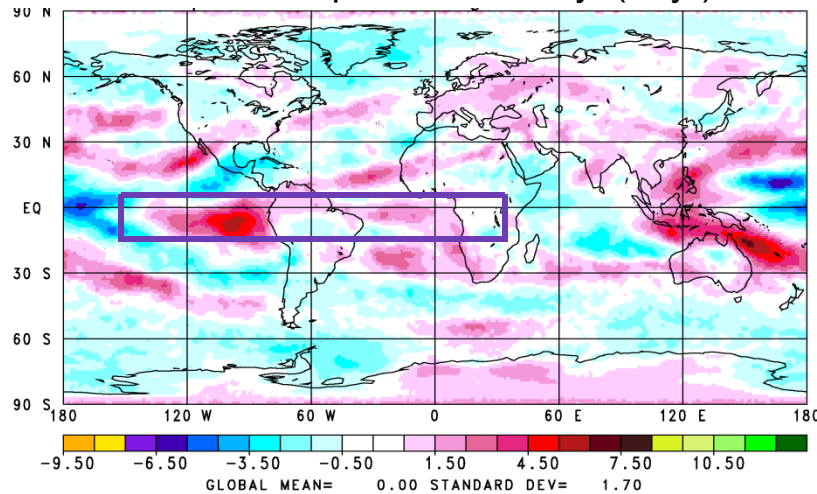


# Effects of El Niño on Water Vapor, Cloud, and OLR Trends

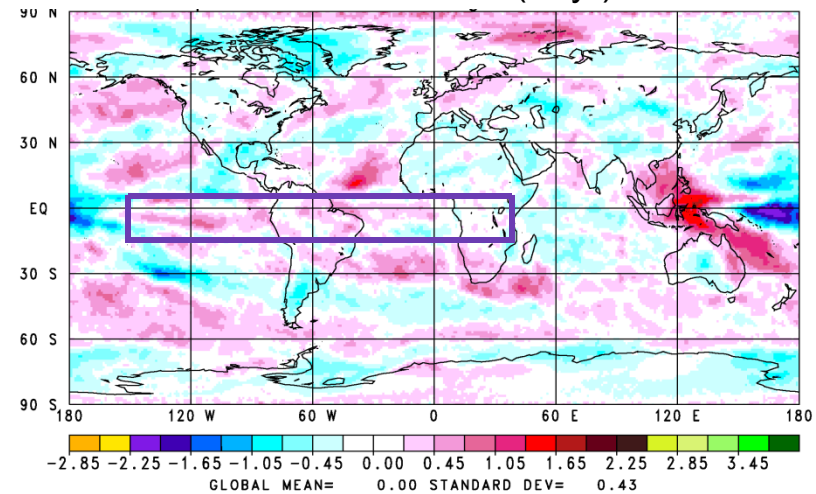
September 2002 through December 2009

5N to 15S. 150W to 30E Boxed in

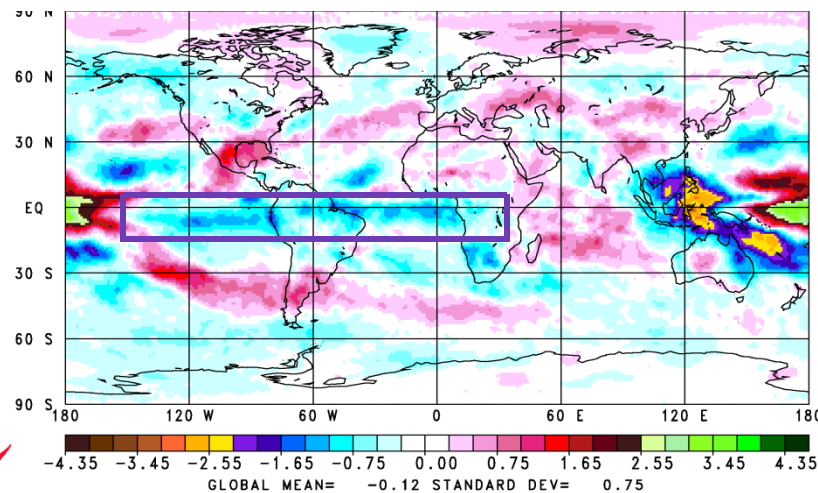
500 mb Specific Humidity (%/yr)



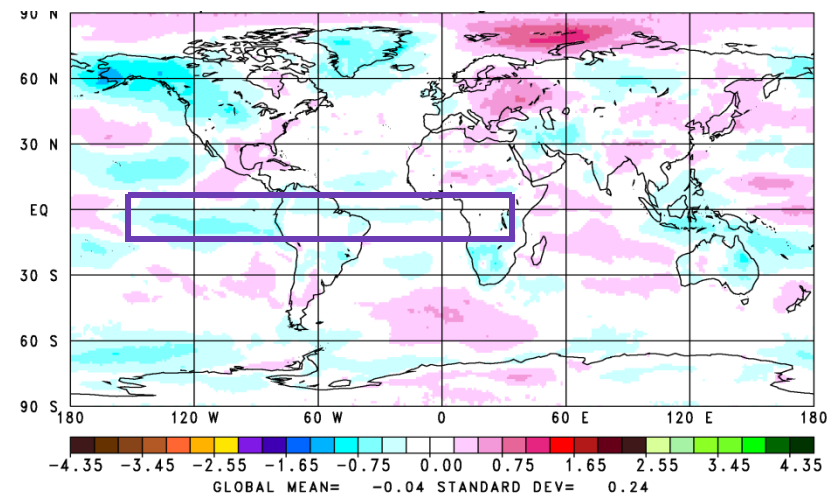
Cloud Fraction (%/yr)



OLR ( $\text{W/m}^2/\text{yr}$ )



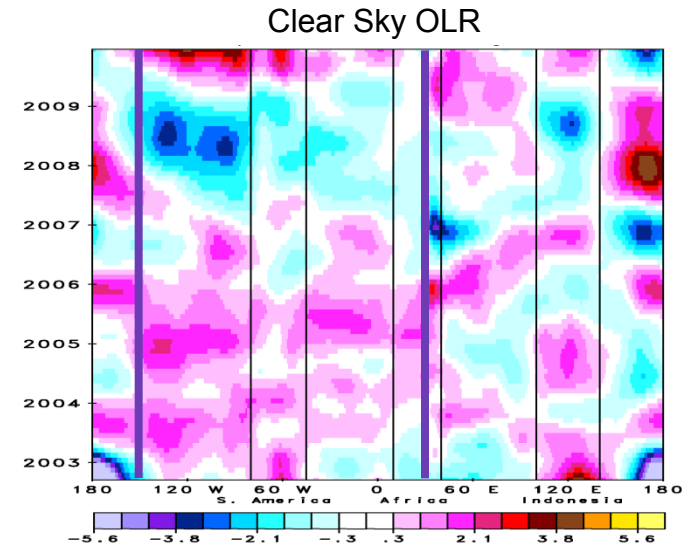
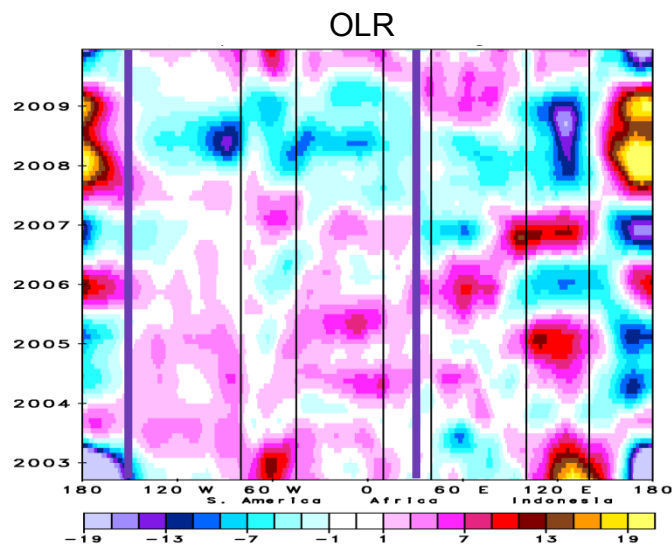
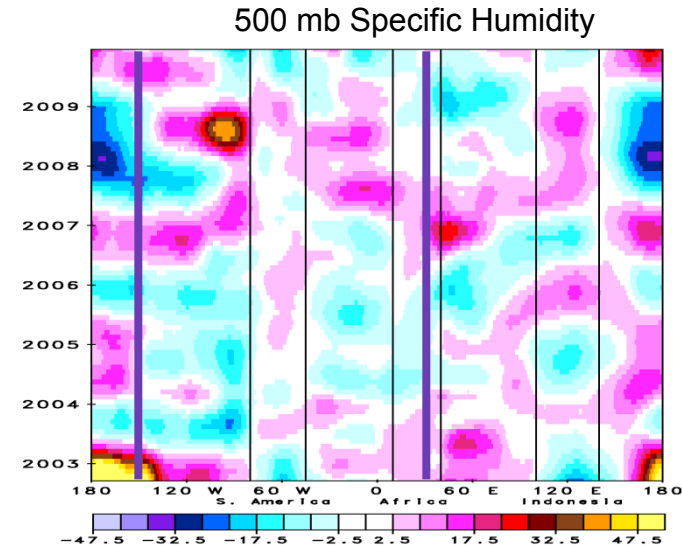
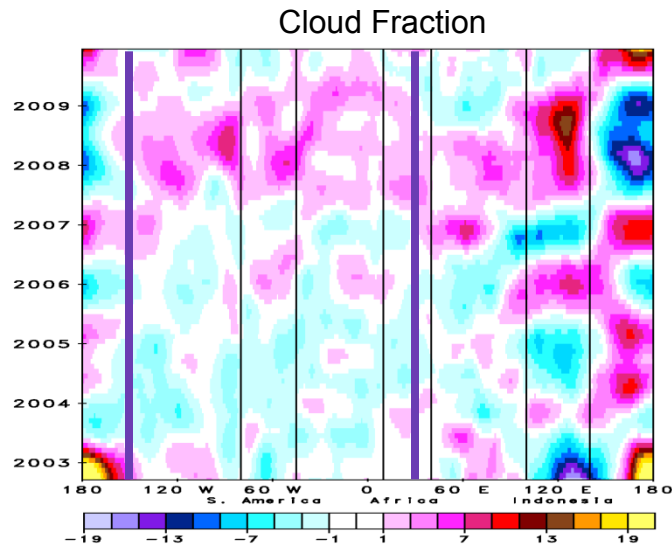
Clear Sky OLR ( $\text{W/m}^2/\text{yr}$ )



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# Effects of El Niño on Water Vapor, Cloud, and OLR Anomalies

AIRS Monthly Anomalies September 2002 through December 2009 Tropics 5N to 5S



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# Attribution of Negative Area Mean OLR Trends

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Trends in 500mb specific humidity and cloud cover are in phase with those of SST in the El Niño and surrounding region causing OLR to decrease significantly near the dateline and increase in the vicinity of Indonesia. Tropical OLR trends in these two areas cancel each other.

The negative zonal mean tropical OLR trend results from a drop in equatorial OLR from 150W eastward to 30E. This results from increasing water vapor and cloud cover in this area during La Niña. Roughly 2/3 of the decrease in tropical OLR results from a decrease in cloud cover and 1/3 from a decrease in water vapor.

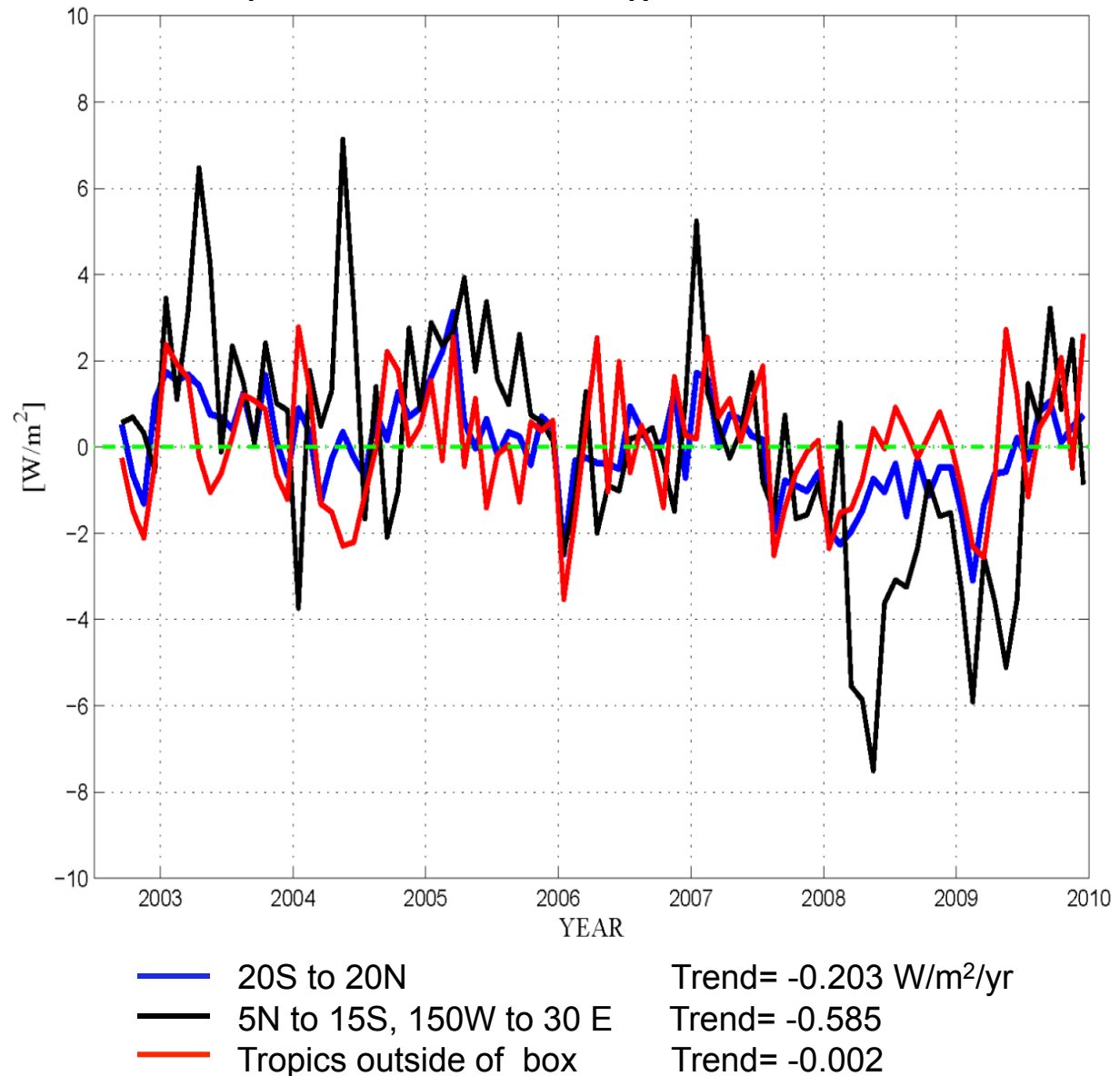




# AIRS Version-5 Tropical All-Sky OLR Anomaly Timeseries September 2002 through December 2009

Removing the area  
5N to 15S,  
150W to 30E from  
area weighted  
statistics  
eliminates the  
tropical negative  
OLR trend

Red line on chart

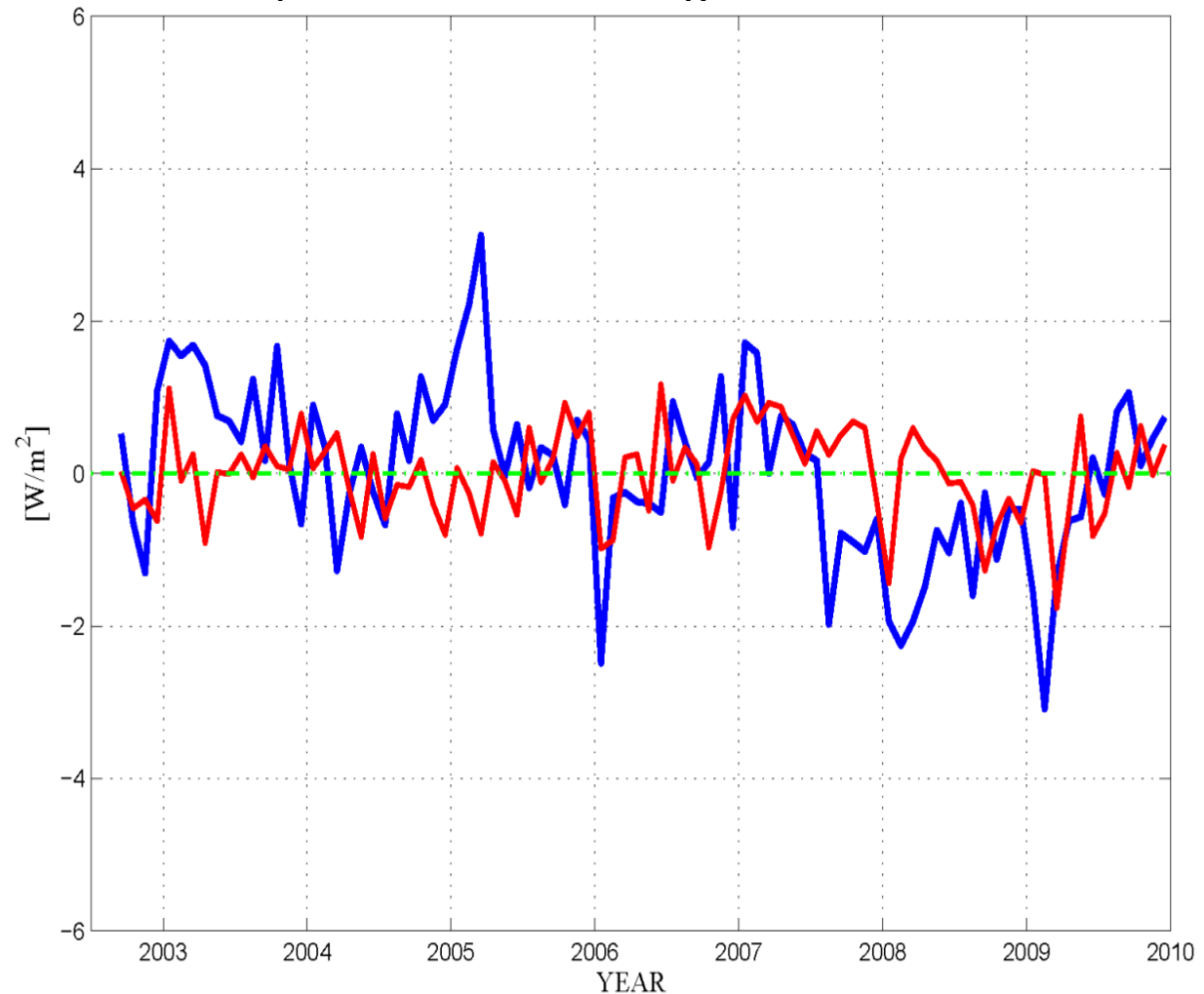


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## AIRS Version-5 Global All-Sky OLR Anomaly Timeseries September 2002 through December 2009

Removing the area  
5N to 15S,  
150W to 30E from  
area weighted  
statistics  
eliminates the  
global negative  
OLR trend

Red line on chart



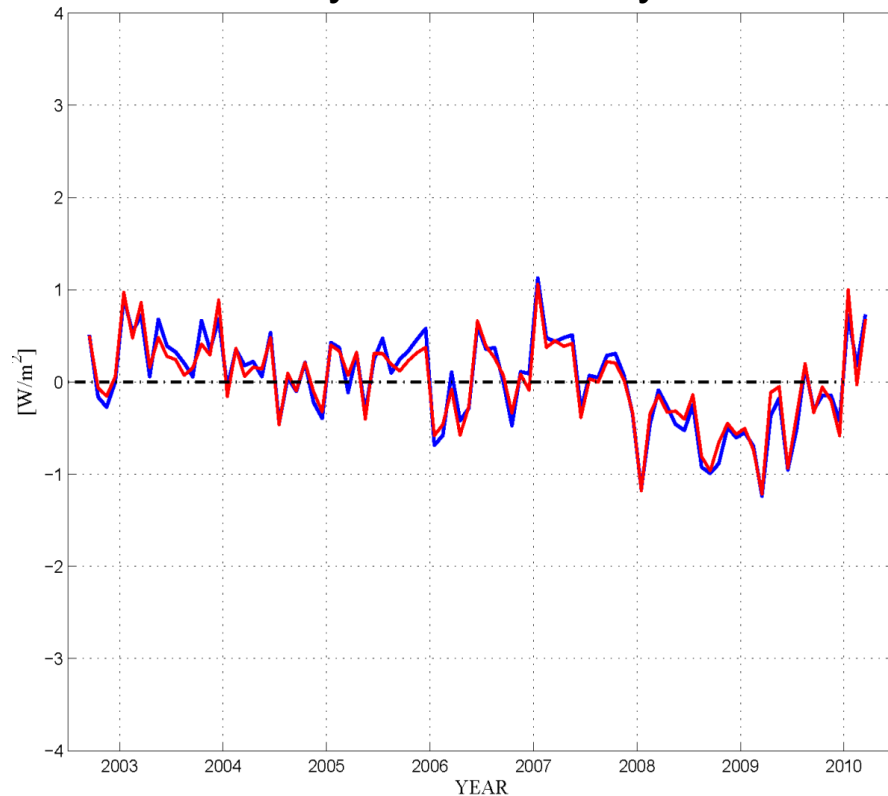
— Global Trend =  $-0.116 \text{ W/m}^2/\text{yr}$   
— Global except for bounding box Trend =  $-0.007 \text{ W/m}^2/\text{yr}$



# Hot off the Press

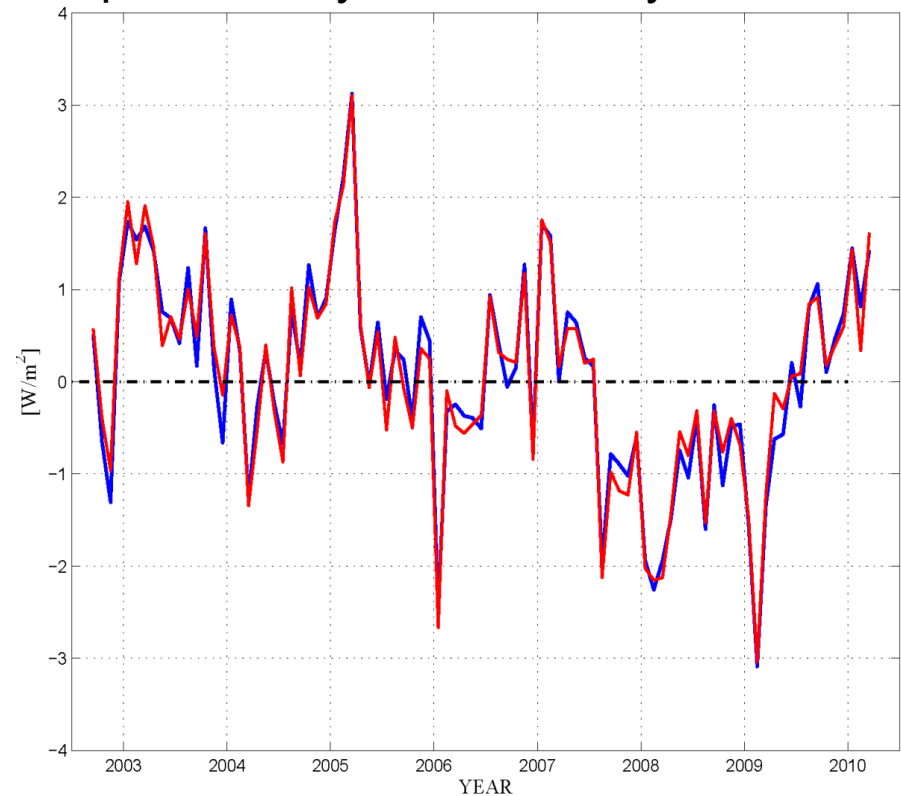
September 2002 through March 2010

Global All-Sky OLR Anomaly Timeseries



— AIRS Version-5 Trend =  $-0.098 \text{ W/m}^2/\text{yr}$   
— Terra CERES Edition-1 Trend =  $-0.092 \text{ W/m}^2/\text{yr}$

Tropical All-Sky OLR Anomaly Timeseries



— AIRS Version-5 Trend =  $-0.166 \text{ W/m}^2/\text{yr}$   
— Terra CERES Edition-1 Trend =  $-0.165 \text{ W/m}^2/\text{yr}$

